

**COMPARISON OF SHEAR BOND STRENGTH OF TWO
ORTHODONTIC BONDING SYSTEMS USED FOR BONDING
CERAMIC BRACKETS(POLYCRYSTALLINE) TO ZIRCONIA
SURFACES**

AN INVITRO STUDY

**THE TAMILNADU DR. M.G.R. MEDICAL
UNIVERSITY**

For partial fulfillment of the requirements for the degree of
MASTER OF DENTAL SURGERY
BRANCH – V

ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS



**THE TAMILNADU DR. M.G.R MEDICAL UNIVERSITY
CHENNAI – 600 032**

2015 – 2018

DECLARATION

I, Dr.T.BHUVANESHWARAN,do hereby declare that this dissertation titled“**COMPARISON OF SHEAR BOND STRENGTH OF TWO ORTHODONTIC BONDING SYSTEMS USED FOR BONDING CERAMIC RACKETS(POLYCRYSTALLINE) TO ZIRCONIA SURFACES - An invitro study**” was done in the Department of Orthodontics, Tamil Nadu Government Dental College & Hospital, Chennai 600 003. I have utilized the facilities provided in the Government Dental College for the study in partial fulfillment of the requirements for the degree of Master of Dental Surgery in the specialty of Orthodontics and Dentofacial Orthopaedics (Branch V) during the course period 2015-2018 under the conceptualization and guidance of my dissertation guide, **Professor and Head of Department, Department of Orthodontics ,Dr.G.Vimala, M.D.S.**

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LIST OF PHOTOPLATES

1.	3M CERAMIC BRACKET KIT	25
2.	ZIRCONIA SLABS	25
3.	TRANSBOND XT -SINGLE BOND-TOTAL ETCH SYSTEM	26
4.	SCOTCH BOND-UNIVERSAL-SELF ETCH SYSTEM	26
5.	ACRYLIC BLOCKS	27
6.	CERAMIC PRIMER	27
7.	LIGHTCURE UNIT	28
8.	HYDROFLUORIC ACID	28
9.	COMPOSITE RESIN ADHESIVE	29

10.	CERAMIC BRACKETS BONDED TO ZIRCONIA SURFACES	30
11.	ARTIFICIAL SALIVA	30
12.	SPECIMENS STORED IN ARTIFICIAL SALIVA	31
13.	INSTRON UNIVERSAL TESTING MACHINE	32
14.	TESTING SHEAR BOND STRENGTH	33
15.	STEREOMICROSCOPE	34
16.	STEREOMICROSCOPE EXAMINATION OF THE DEBONDED SURFACES	34
17.	STEREO MICROSCOPE VIEW OF DEBONDED ZIRCONIA SURFACE –AFTER USE OF TRANSBOND XT, AND SCOTCHBOND	34

LIST OF ABBREVIATIONS

SBS	Shear Bond Strength
ARI	Adhesion Remnant Index
MPa	Mega Pascal
N/mm ²	Newton/millimeter square
SEM	Standard Error Mean
MDP	MethacryloxydecylDihydrogen Phosphate

CONTENTS

S.NO.	TITLE	PAGE NO.
1.	INTRODUCTION	01
2.	AIMS AND OBJECTIVES	03
3.	REVIEW OF LITERATURE	04
4.	MATERIALS AND METHODS	21
5.	RESULTS	35
6.	DISCUSSION	48
7.	SUMMARY AND CONCLUSION	55
8.	BIBLIOGRAPHY	57

LIST OF TABLES

S. No.	TOPIC	PAGE No.
1	Shear Bond Strength	38
2	Group Statistics	39
3	Independent Samples Test	40
4	Adhesive Remnant Index	42
5	Groups * Adhesive Remnant Index Crosstabulation	43
6	Chi-Square Tests	44

LIST OF GRAPHS AND CHARTS

S. No.	TOPIC	PAGE No.
1	Showing comparison of Shear Bond Strength	41
2	Showing comparison of Adhesive Remnant Index	45
3	Showing comparison of Mean Peak Value of Adhesion Remnant Index	46

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TRIPARTITE AGREEMENT

This agreement herein after the “Agreement” is entered into on this day.....January 2018 between the Tamil Nadu Government Dental College and Hospital represented by its Principal having address at Tamilnadu Government Dental college and Hospital, Chennai-03, (hereafter referred to as ,’the college’)

And

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And

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INTRODUCTION

Fixed appliance mechanotherapy in adults has gained immense popularity in the recent years. In addition, aesthetics even during orthodontic treatment is given much priority resulting in the use of ceramic brackets. As it is not uncommon to see adults with ceramic prosthetic teeth, direct bonding of a ceramic bracket onto ceramic surfaces become inevitable and it requires that bond strength between ceramic brackets and ceramic surfaces are adequate.^(1,2)

Among the plethora of bonding agents available in the recent years for direct bonding in orthodontics, the advent of one step adhesives in orthodontics, with special primers containing the monomer 10-methacryloxydecyl dihydrogen phosphate (MDP) is a breakthrough in this regard as they reduce material cost, minimize chair side time and avoid hydrofluoric acid which is otherwise used for etching porcelain surfaces.

These one step adhesives were commercialized in late 2002 with the main advantage of etching and application of a bonding agent combined into a single step. As no additional primers are needed, bonding to prosthetic surfaces is also simplified. Due to aqueous components contained in the primers, such adhesives are useful even in a moist environment.⁽³⁾

Adequate shear bond strength is a prime requisite for a direct bonding material used in fixed appliance mechanotherapy. The bond strength values for conventional adhesive systems on enamel ranges between 8 and 30 MPa⁽⁴⁾. Such bonds should withstand the forces occurring in the moist oral environment. It is equally important that it must also be capable of being removed without residue, without causing damage to the enamel or the prosthetic crowns.⁽⁵⁾ The ideal shear bond strength prescribed for

conventional bonding of brackets on enamel surfaces is 4 to 10 MPa.⁽⁶⁾ Hence shear bond strength on restorative materials and prosthetic surfaces should be at least as high as those on enamel, in order to prevent high rates of debonding.

With this perspective, it is elemental to identify the best bonding system that imparts and acceptable shear bond strength and adhesive remnant index.

Though studies have been done comparing the shear bond strength of metal brackets on prosthetic surfaces using various adhesives ^(7,8,9,10,11) no such study has been documented so far, comparing shear bond strength of ceramic brackets on zirconia crowns .Hence this study was conducted to compare shear bond strength of two different orthodontic bonding systems(Scotchbond universal,Transbond XT primer) used for bonding ceramic brackets to zirconia surfaces.

AIM

To evaluate efficiency of two bonding systems namely, i) Self-etching primer and ii) Total etch system , used to bond ceramic brackets to zirconia crowns

OBJECTIVES

1. To find shear bond strengths while using the two bonding systems for bonding ceramic brackets to zirconia surfaces.
2. To find Adhesive remnant index score upon debonding, after using the two bonding systems.

REVIEW OF LITERATURE

Buonocore, 1955⁽¹⁶⁾ demonstrated adhesion of filling materials to enamel using 85% solution of phosphoric acid for acid etching for enamel.

Bowen ,1963⁽²⁵⁾ experienced on reinforced epoxy resins with filler particles and developed the composite material consisting of silane coated silica filler in BIS-GMA resin binder.(Bowen's resin)

Newman, 1965⁽¹²⁾ introduced the concept of treating enamel surface by applying 40% phosphoric acid to enhance adhesive strength.

Reynolds, 1975⁽¹³⁾ reported that clinically, the bonded brackets should be able to withstand forces generated by treatment mechanics and occlusion, yet allow easy debonding without enamel damage . A maximum tensile bond strength of 5.9 to 7.9 MPa would be adequate resist treatment forces but added that invitro tensile strength levels of 4.9 MPa have proved clinically acceptable.

Zachrisson, 1977⁽¹⁴⁾for the first time carried out a post treatment evaluation of direct bonding of metal brackets with a composite material might be a successful procedure for a full period of orthodontic treatment .To reduce the failure rate ,it was important to improve the clinical operative procedure rather than to increase the retentive strength of the adhesives.

Jon Artun and Sven Bergland ,1984⁽¹⁵⁾conducted clinical experiments to test the applicability of crystal growth conditioning as an alternative to acid-etch enamel pre-treatment using two test solutions containing sulfuric acid. This was done to find out whether debonding and subsequent adhesive clean up where easier and quicker with the sulfuric acid treatment when compared to phosphoric acid etching. They also

determined whether clinically the two enamel conditioning methods resulted in similar or different failure rates in terms of the number of loose brackets. They developed an adhesive remnant index on the basis of a pilot study on twenty extracted teeth and gave the criteria with four scores. In their in vivo study, they concluded that the failure rates were significantly higher after enamel conditioning with dilute sulfuric acid containing sodium sulphate than after conditioning with a solution containing dilute sulfuric acid plus 10% phosphoric acid and after conditioning with this latter solution than after phosphoric acid etching. They also reported that nearly all the brackets became loose during the first two weeks of bonding subsequent to dilute sulfuric acid conditioning. The failure rates occurred at a later point of time when conditioning with the combination solution of dilute sulfuric acid plus 10% phosphoric acid.

Sheldon.M Newman et al (1984)⁽²⁾ tested the ability to bond orthodontic brackets to porcelain and a heat cured composite resin with a normal direct bonding technique. They used silane to enhance the bond to porcelain and the glass component of the composite. This was compared to a normal acid etch procedure to enamel. They concluded that silane did not significantly affect the bond strength; though it enhanced the composite bonding of brackets to prosthetic porcelain restorations it required constant monitoring since the bond might not be clinically sufficient.

David wood et al (1986)⁽¹¹⁾ tested the effectiveness of bonding orthodontic attachments to porcelain, edgewise brackets were bonded to 160 lower incisor, porcelain denture teeth by means of two different resin systems and three different porcelain bonding agents. They found that the use of a porcelain primer before bonding resulted in shear strengths comparable to those achieved with conventional acid-etch enamel bonding. They also reported that roughening the porcelain surface

and bonding with a heavily filled resin without a porcelain primer provided shear strengths comparable to conventional acid-etch enamel bonding with a lightly filled resin. They thus concluded that roughening the porcelain surface before bonding, adding porcelain primers, and using highly filled resins all added significantly to bond strength, but caused a progressively greater risk of porcelain fracture during debonding.

George F. Andreasen, and Mark A. Stieg, 1988⁽¹⁷⁾ reported techniques for bonding orthodontic brackets to porcelain and gold surfaces. They described two techniques – one with hydrolysed silane agent and another with non –hydrolysed silane agent for bonding brackets to porcelain. Phosphoric acid was used as an etchant in both the techniques.

Sheth J, Jensen M and Tolliver D, 1988⁽¹⁸⁾ evaluated the effect of mechanical retention by etching and chemical bonding by silanizing porcelain surfaces on their shear bond strength to etched enamel. They also studied the effect of applying fit – checker paste to etched porcelain surface and examined the same before and after re – etching .They concluded that optimum bond strength of porcelain to etched enamel was obtained by both etching and silanizing the surface. They also advised caution when using a silicone based fit checker paste.

John Gwinnett, 1988⁽¹⁹⁾ compared the shear bond strength of metal and ceramic brackets and concluded that ceramic brackets and concluded that ceramic and ceramic filled plastic brackets offered a viable alternative to their metal counterparts by combining aesthetics and comparable shear bond strengths.

Matasa, 1989 ⁽²⁰⁾ enumerated the requisites of adhesives to be :Resistant ambient environment ,at the same time protecting the interfaces, Be fluid enough, set hard and tough, Tolerate /Dissolve tiny amounts of impurities, not cure slowly, unduly shrink or allow discontinuities.

Zachrisson et al,1993⁽²¹⁾ recommended sand blasting of porcelain surface and obtain strong bonds followed by etching with an hydrofluoric acid and APF gel .They also suggested that silane primers could increase bond strength.

Vanessa Leal Tavares Barbosa et al, 1995⁽²²⁾ compared various preparatory procedures and bonding materials to find out a method that produced adequate bond strength when bonding brackets to porcelain. They concluded that additional mechanical retention with a coarse diamond bur and further chemical bonding with a silane priming agent were necessary after the application of acidulated phosphate fluoride when bonding orthodontic brackets to porcelain surface.

Paul W. Major et al, 1995⁽⁹⁾ compared the bond strength of three types of adhesion promoters –Ormco Porcelain Primer, All – Bond2, Scotch prime Ceramic primer with two orthodontic adhesives namely Phase II and Rely-a-bond. They concluded that there were significant differences between all the primer/adhesive combinations except for Scotch prime and Ormco Primer that were not statistically different. Scotch Prime showed more consistent results on the basis of standard deviations alone. Also Phase II resin resulted in higher bond strengths but increased the incidence of porcelain fracture on debonding.

Zachrisson et al ,1996⁽²³⁾ evaluated the effect of various porcelain surface treatments on the tensile strength of orthodontic brackets bonded to a feldspathic metal ceramic porcelain. The surface treatments tested were sandblasting, silane application, with or without additional use of bond reinforcing intermediate resin. They compared these bond strengths with those obtained with porcelain etchants .They concluded that silane application to the sandblasted porcelain surface significantly increased the bond strength. The quality of the bonds was further enhanced by the addition of the intermediate resin. They also found that etching the porcelain with 9.6% hydrofluoric acid provided similar bond strengths, but not so with the 4% APF gel.

Devin Cochran, Kathy L. O'Keefe, David T. Turner and John M. Powers, 1997⁽²⁴⁾ studied orthodontic bond strength of composite cement and and treated procedure by preparing a porcelain fused to metal ceramic by five treatments sandblasting, sandblasting and silanating,hydrofluoric acid etching, hydrofluoric acid etching and silanating, and 600-grit polishing and silanating. Two commercial, all-purpose bonding agents were used to bond a composite cement to the porcelain samples. In vitro tensile bond strengths were compared with samples for which no bonding agent was used.Composite cement bonded without bonding agent to nonsilanated porcelain prepared by sandblasting or etching with hydrofluoric acid had bond strengths of 6.5 MPa and 18 MPa, respectively, with all bond failures at the bracket/composite interface. They concluded that the use of all-purpose bonding agents and silanating agents may not be necessary for adequate orthodontic direct bonding.

Immanuel Gillis, and Meir Redlich, 1998⁽⁶⁾ in their study titled ‘The effect of different porcelain conditioning techniques on shear bond strength of stainless steel brackets’, concluded that hydrofluoric acid conditioning technique produced greater shear bond strength than both diamond roughening and micro etching. After debonding by means of a shearing force, the percentage of damaged porcelain surfaces in the silane+Concise groups was significantly higher than the silane+Right-On and High-Q-Bond groups, the three groups being the three different dental adhesive used.

Selim Arici and Chris Minors, 2000⁽²⁸⁾ measured the in vitro force levels generated by four differing methods of mechanical debonding techniques for ceramic brackets using debonding pliers. They stated that the clinical debonding strength values would be lower than those they had reported. They thus concluded that the forces required to initiate debonding of ceramic brackets were related to the contact area between the tips of the pliers and the adhesive which could be decreased by using pointed plier tips or by placing the debonding plier diagonally opposite of the brackets. To make the debonding force more controllable, they suggested the use of a screw (as in a handpiece) to apply the debonding force.

E. Bishara, Leigh VonWald, BS, John F. Laffoon, BS and John J. Warren, 2001⁽²⁹⁾ studied the effect of a self-etch primer/adhesive on the shear bond strength of orthodontic brackets. Three different agents (an enamel conditioner, a primer solution, and an adhesive resin) were used for bonding of orthodontic brackets to enamel. The results indicated that a newly introduced self-etch primer, which contained both the

enamel etchant and primer, had the potential to successfully bond orthodontic brackets.

Lina P. Theodorakopoulou, 2001⁽³⁰⁾ compared the shear bond strength and the bond-failure location of two currently available orthodontic ceramic brackets. Results indicated that the safest removal practice to reduce the chance of enamel damage was the debonding technique specifically designed for each ceramic bracket as the mean shear bond strengths of both the poly and mono crystalline brackets tested were higher than those considered optimal.

Kevin L. Pickett et al, 2001⁽⁵⁾ tested a new in vitro debonding device and compare in vivo bond strengths recorded by this device with in vitro bond strengths recorded by a universal testing machine such as the Instron. The results indicated that mean bond strengths recorded in vivo following comprehensive orthodontic treatment were significantly lower than bond strengths recorded in vitro.

Bishara SE, Ajlouni R, Laffoon JF and Warren JJ, 2002⁽²⁷⁾ assessed the effects of a fluoride releasing primer compared to that of self-etching primer on the SBS of orthodontic brackets and concluded that, the mean SBS of the fluoride-releasing primer and the self-etching primer was significantly lower than that achieved using conventional acid etch technique.

Arndt Klocke, ; Jianmin Shi, Ba'rbel Kahl-Nieke and Ulrich Bismayer, 2003⁽³¹⁾ evaluated bond strength for a custom base indirect bonding technique using a hydrophilic primer on moisture-contaminated tooth surfaces and concluded that the bond strength for the custom base indirect bonding technique with the hydrophilic primer was not significantly different in groups without contamination and with water

or saliva contamination before application of the primer. Whereas, moisture contamination after application of the hydrophilic primer resulted in significantly lower bond strength measurements compared with bond strength for uncontaminated enamel.

Jia-Kuang Liu, Ching-Hung Chung, Chuan-Yang Chang, and Dar-Bin Shieh, 2005⁽³²⁾ evaluated the shear bond strength and debonding characteristics of a new collapsible mono crystalline bracket and concluded that there were no statistically significant differences in bond strengths among the different combinations of brackets and adhesives. The failure mode after debonding either during shear bond strength testing or with pliers was predominantly at the bracket/adhesive interface.

Keiichi yoshida, yukiko tsuo, Mitsuru atsuta, 2005⁽³³⁾ evaluated the shear bond strength between dual-cured resin luting cement and pure zirconium and industrially manufactured yttrium-oxide-partially stabilized zirconia ceramic, and the effect of MDP (10-methacryloyloxydecyl dihydrogen phosphate) primer (MP) and zirconate coupler (ZC) on bond strength. They found out that the application of the mixture of MP and ZC was effective for bonding between zirconia ceramic and dual cured resin luting cement.

Cehreli ZC, Kecik D and Kocadereli, 2005⁽³⁴⁾ assessed and compared the SBS of orthodontic brackets bonded to intact bovine mandibular incisors using four self-etching primer and adhesive formulations, a non-rinse conditioner and acetone adhesive system and a conventional system. The authors concluded that the SBS of

the self-etching primer and adhesive systems tested were much lower than that of the conventional acid etch and bond system.

Julio Pedra e Cal-Neto et al,2006⁽³⁵⁾ evaluated in vitro , a new self-etching primer on bracket bond strength and indicated that self-etching primer was potentially adequate for orthodontic bonding needs ; the amount of adhesive on enamel after debonding was significantly less when using self-etching primer than when using phosphoric acid.

H. Korbmacher , L. Huck , T. Adam and B. Kahl-Nieke ,2006⁽³⁶⁾evaluated an antimicrobial and fluoride-releasing self-etching primer on the shear bond strength of orthodontic brackets and indicated that the use of this primer provided acceptable bond strength , leaving less composite on the tooth surface .

Marcus Holzmeier, Martin Schaubmayr, Walter Dasch and Ursula Hirschfelder,2007⁽³⁷⁾determined the shear bond strength , etching pattern and depth, and debonding performance of a new generation of self-etching adhesives in comparison with traditional acid etch technique and concluded that the self-etching adhesives currently used mainly in restorative dentistry exhibited less etching potential than phosphoric acid-etching.

Regina Amaral et al ,2007⁽³⁸⁾evaluated the durability of bond strength between a resin cement and aluminous ceramic submitted to various surface conditioning methods. They concluded both laboratory and chair side silica coating followed by silanization showed durable bond strength of the resin cement to glass-infiltrated zirconia–alumina ceramic.

Manar K.A. Hajrassie and Salwa E. Khier,2007⁽³⁹⁾ measured and compared In-vivo and in-vitro comparison of bond strengths of orthodontic brackets bonded to enamel and debonded at various times. They concluded that the bond strength values are not time dependent. They also reported that the in-vivo bond strengths are lower than those reported in vitro.

Sevinc Karan et al ,2007⁽⁶⁰⁾ determined the effects of various surface conditioning methods on 3 types of ceramic materials (feldspathic, leucite-based, and lithium disilicate-based) in orthodontic bonding. They concluded that silica coating technique could replace the other conditioning techniques in bonding brackets to ceramic. They however cautioned to exercise care during debonding because of the risk of porcelain fracture.

Masahiro IJIMA et al,2008⁽⁴⁰⁾ compared the bond strengths and conducted scanning electron microscopic evaluation of three orthodontic bonding systems. They concluded that both the self-etching primers showed a milder etching effect than that observed for 35% phosphoric acid. Both self-etching primers produced shallower depth of resin penetration into intact enamel as compared to using 35% phosphoric acid as an etchant and saliva contamination of enamel after priming had little adverse effect on bond strength when self-etching primers were used.

M. Özcan , K. Finnema and A. Ybema ,2008⁽⁴³⁾ evaluated the effect of silanization on the failure type and shear – peel bond strength (SBS) of ceramic and polycarbonate brackets and concluded that silanization did not significantly improve the mean bond strength results either for the ceramic or polycarbonate brackets. Failure type was not

significantly different when brackets were debonded with a universal testing machine or with orthodontic debonding pliers, and no enamel damage was observed in any of the groups.

Funda Bayindir ,Fatma Taşpinar and M.Şamil Akyil ,2008⁽⁴²⁾evaluated the effect of orthodontic bonding of composite and ceramic brackets on porcelain and acrylic resin surfaces .They stated that acrylic resin surfaces were affected mostly compared to porcelain surfaces when both composite and ceramic brackets were bonded to these surfaces with light cure adhesives. Also the acrylic resin samples displayed some cracks in such situations. Hencethey concluded to use no mix adhesives to avoid surface cracks on acrylic resin surfaces and for better bond strength on porcelain surfaces.

Mutlu Ozcan et al ,2008⁽⁴¹⁾evaluated effect of evaluated the effect of chair side and laboratory types of surface conditioning methods on the adhesion of dual cure resin cement with MDP functional monomer to zirconia ceramic after thermocycling. They concluded that the chair side conditioning methods based on microabrasion and silane treatment was on par with the laboratory alternative tested.

Elham S. J. Abu Alhaija, Issam A. Abu AlReesh and Ahed M. S. AlWahadni,2009⁽⁸⁾studied the factors affecting the shear bond strength (SBS) of metal and ceramic brackets bonded to different ceramic surfaces and concluded that the type of surface treatment was the only factor that significantly affected SBS. The pattern of bond failure of metal brackets was at the adhesive–restorative interface, whereas for the ceramic brackets it was at the adhesive–bracket interface.

Kern. M etal ,2009⁽⁴⁴⁾evaluated various surface conditioning parameters like air abrasion and primers, on the long term resin bond strength to zirconia ceramic. They concluded that when luting resins were used without adhesive monomer, the combination of air abrasion and priming was necessary to achieve durable long term bonding to zirconia ceramic. They also recommended air abrasion at lower pressures with appropriate adhesive primers to obtain long term bond strength between resin composites and zirconia ceramics.

Bianca Mota Santos, Matheus Melo Pithon, Antonio Carlos de Oliveira Ruellas and Eduardo Franzotti Sant'Anna , 2010⁽⁴⁵⁾ compared in vitro the Shear bond strength of brackets bonded with hydrophilic and hydrophobic bond systems under contamination. They concluded that in both systems, the weakest mean bond strength was achieved in the presence of blood and the use of a hydrophilic bond system should be considered with blood exposure.

Rondell Blakey and James Mah,2010⁽¹⁾ tested in vitro, the effect of different surface treatments on the shear bond strength of metal and ceramic orthodontic brackets bonded to temporary polycarbonate crowns and suggested that - Etching polycarbonate crowns with 9.6 hydrofluoric acid was completely ineffective for increasing the shear bond strength and Ceramic brackets bonded to sandblasted polycarbonate crowns produced the highest shear bond strength, although below a level that was comparable with other clinically acceptable bond strengths.

Finnema KJ, Ozcan M, Post WJ, Ren Y and Dijkstra PU,2010⁽⁴⁷⁾ in their systematic review and meta-analysis extensively reported the factors affecting *in-vitro* orthodontic bond strength testing and concluded that the experimental conditions that

considerably influenced *in-vitro* bond strength were storage of the bonded specimens in water, photopolymerization time and crosshead speed.

Mandava Prasad et al,2011⁽⁴⁸⁾ investigated the effect of moisture, saliva, and blood contamination on the shear bond strength of brackets bonded with a conventional bonding system and self-etched bonding system. They concluded that the conventional bonding system showed higher shear bond strength values than the self-etch bonding system under dry enamel surface conditions. The self-etch bonding system showed higher shear bond strength values than the conventional bonding system under all wet conditions. In both the systems, the weakest mean bond strength was achieved in the presence of blood contamination. The use of the self-etch bonding system showed clinically acceptable bond strength under moisture and saliva contaminations.

Sasiwimol sanohkan et al,2012⁽⁴⁹⁾ studied the effect of various primers on shear bond strength of zirconia ceramic and resin composite and concluded that the shear bond strength values between zirconia ceramic and resin composite using various primers were not significantly different. The mode of failure for all specimens was found to be adhesive failure at the ceramic and bonding agent interface.

Magáli Beck Guimarães et al,2012⁽⁵⁰⁾ evaluated the *in vitro* shear bond strength of orthodontic accessories to porcelain, under different porcelain surface treatment protocols, and the resultant failure pattern after debonding. They concluded that the use of phosphoric acid followed by silane application was the best protocol for bonding orthodontic accessories to porcelain surfaces, since it was capable of resisting

the forces applied during orthodontic treatment without causing irreversible failures in restorations.

Fundagul Bilgic et al, 2013⁽⁵¹⁾ determined the shear bond strength (SBS) of ceramic brackets bonded to three different porcelain surfaces. They concluded silane coupling agents and hydrofluoric acid would be appropriate for chemical alteration of the porcelain surface. They also found no statistically significant differences in the bond strength between IPS e-max ceramic crown and porcelain fused to zirconia crown groups , though both these groups showed significantly higher bond strengths than conventional porcelain fused to metal crown groups.

Sudhir Sharma et al, 2013⁽⁵²⁾ compared the shear bond strengths of orthodontic brackets bonded with four different orthodontic adhesives and concluded that the highest SBS was observed in Transbond XT, followed by Xeno V with Xeno Ortho, Rely-a-Bond and lowest in Transbond Plus with Transbond XT. In Transbond Plus with Transbond XT group and in Xeno V with Xeno Ortho group, most of the adhesive remained on the bracket indicating failure at the enamel-adhesive interface. Whereas, in Transbond XT group and Rely-a-Bond group, most of the adhesive remained on the tooth, indicating failure at the bracket-adhesive interface.

Kumaraswamy Anand M, Kaberi Majumder, Sundaram Venkateswaran and Rengarajan Krishnaswamy N, 2014⁽⁵³⁾ investigated the effectiveness of two hydrophilic primers with respect to conventional hydrophobic primer by comparing their shear bond strength (SBS) and adhesive- failure locations after contamination with saliva and saliva substitute. They concluded that SBS produced by Transbond

MIP groups was significantly higher than that of Opal Primo groups. Both test groups showed lesser bond strength values when compared with Transbond XT. However, the bond strength of the study groups was much higher than the recommended clinical bracket bond strength of 6-8 MPa. - Lower ARI scores suggested more frequent failure between adhesive and enamel for Transbond MIP and Opal Primo groups compared with higher ARI score for Transbond XT and hence the tooth cleanup procedure after debonding was easier and faster for Transbond MIP and Opal Primo groups than Transbond XT.

Waleed Bakhadher, Hassan Halawany, Nabeel Talic, Nimmi Abraham and Vimal Jacob,2015⁽⁵⁴⁾ in their literature review revealed that both material- and teeth-related factors influenced the SBS of orthodontic brackets. Within its limitations, using conventional acid-etch technique, ceramic brackets and bonding to non-fluorotic teeth was reported to have a positive influence on the SBS of orthodontic brackets, but higher shear bond strength found on using ceramic brackets could be dangerous for the enamel.

Takamizawa Toshiki et al ,2015⁽⁵⁵⁾ studied the influence of water storage on fatigue strength of self-etch adhesives and found that the fatigue strength of the self-etch adhesives was dependent on the adhesive material, storage period and phosphoric acid pre-etching of the bonding site.

Thomas Ebert, Laura Elsner, Ursula Hirschfelder and Sebastian Hanke, 2016⁽⁵⁶⁾ analysed surfaces consisting of different restorative materials for shear bond strength (SBS) and failure patterns of metal and ceramic brackets and found that the universal primer (Monobond plus) generated high bond strengths of both metal and ceramic brackets on all the six restorative surfaces. They also concluded that temporary clinical bonding of brackets to composite resin or glass–ceramic surfaces is not a recommended application for Monobond Plus, considering the fracture risk of these materials in the presence of high bond strengths and recommended the use of a chemically cured primer whenever materials of this type are combined.

Magáli Beck Guimarães et al , 2016⁽⁵⁷⁾ evaluated the shear bond strength of orthodontic accessories bonded to a porcelain surface after storage in water for 150 days. They concluded that the phosphoric acid etching of the porcelain surface with or without the silane bonding agent, did not provide adequate shear bond strength in such a wet condition. Such storage of the specimens in water for decreased the bond strength at salinized interfaces. They also stated that though Surface conditioning with hydrofluoric acid with or without silane generates adequate bond strength it increased the fracture rate in porcelain.

Andreas Hellak et al, 2016⁽⁷⁾ determined the shear bond strength and adhesive remnant index score of two self-etching no-mix adhesives on different prosthetic surfaces and enamel, in comparison with a commonly used total etch system for bonding metal brackets. They concluded that one of the self-etching no mix

adhesives(Scotch bond universal) provided the best bonding on all other type of surfaces (Metal,Acrylic,Porcelain) with no need for additional primers.

Blerim Mehmeti et al ,2017⁽⁵⁹⁾ compared the shear bond strength of metallic and ceramic orthodontic brackets bonded to all –zirconium ceramic crowns and concluded that metallic brackets created stronger adhesion with all zirconium surfaces due to their better base surface design or retention mode. The ceramic brackets showed higher fragility during debonding.

MATERIALS AND METHODS

- Polycrystalline ceramic brackets. (3M Unitek, Monrovia, California, USA)
- Zirconia blocks (3 mm thickness / 10 x 12 mm dimension) –total 24 surfaces. (IPS e.max ZIRCAD)
- Acrylic blocks – 1.5x1.5x4 cms dimension.
- Scotchbond- Universal-(3M Unitek Monrovia, California, USA)
- Transbond XT- Single bond-(3M Unitek Monrovia, California, USA)
- Ceramic primer--(3M Unitek Monrovia, California, USA)
- Hydrofluoric acid (Ultradent)
- visible light curing unit (CU 100 A, Densply)
- Composite (Transbond XT -3M Unitek Monrovia, California, USA)
- Saliva substitute (ICPA health products, India)
- Instron universal testing machine - Load cells available 100 N, 1 KN and 100 KN
- Stereo microscope X 40 magnification. (LEICA-M)

Specimen preparation:

Two sets of colour coded acrylic blocks were prepared. The prefabricated zirconia slabs were embedded each, in one of the surfaces of the acrylic blocks. The pink Colored blocks, called GROUP 1 (N= 12) housed 12 Zirconia surfaces and the remaining purple Color coded blocks, called GROUP 2 (N= 12) housed 12 zirconia surfaces.

The Polycrystalline ceramic brackets were bonded to the zirconia surfaces on the specimens using two types of bonding systems.

Group-1

Total etch system-Transbond XT adhesive-(3M Unitek Monrovia, California, USA)

Group-2

Self-etching-no mix system –Scotchbond Universal adhesive (3M Unitek Monrovia, California, USA)

Bonding procedure:

In Group 1 –Hydrofluoric acid etchant was first applied to zirconia surface for 30 seconds, washed with water, dried. Ceramic primer was then applied and cured for 20 seconds following which transbond XT was applied and cured for 20 seconds using CU

100 ADENTSPLY visible light cure unit. TransbondXT was also applied to the bracket base and light cured by the same source for 20 seconds.

In Group 2- scotch bond universal was applied to zirconia surface and bracket base and cured for 20 seconds each using CU 100 A DENTSPLY visible light cure unit.

Transbond XT composite was finally used to bond the upper central incisor ceramic bracket in both Groups (1 & 2) to the cured Zirconia surface mentioned above using the same light source.

TESTING SHEAR BOND STRENGTH

All the specimens were stored at room temperature in the saliva substitute for 24 hours before testing.

The specimens were tested for shear bond strength using an INSTRON UNIVERSAL TESTING MACHINE (No 3382). The acrylic block was fixed to the lower fixed jaw with the brackets perpendicular to the floor. The cross head was driven by a vertical chisel and speed of 1mm/ min was set. This chisel applied a shearing force passing parallel to the interface between bracket base and zirconia surface, thus debonding the bracket. The point at which the bracket separated from the tooth was considered as the breaking load which was digitally displayed in the machine. The force required to debond each bracket was registered in Newtons, and converted in to Megapascals by using the following formula:

Bond strength = Breaking load/Nominal area of bracket base, N/mm² or Mpa

This results were statistically analysed using **Indepentant T Test** used to measure shear bond strength.

Adhesive remnant index

All specimens subsequent to debonding were examined under a stereomicroscope of x 40 magnification to assign adhesive remnant index. **Chi-square test** was used to test Adhesive Remnant index score among two groups.

ADHESIVE REMNANT INDEX ⁽¹⁵⁾

The amount of residual adhesive was classified using the adhesive remnant index developed by Artun and Bergland.

This consist of a 4 point scale of 0 to 3

0-Indicates no adhesive left on the tooth

1-Indicates less than half of adhesive left on the tooth

2-Indicates more than half of adhesive left on the tooth

3-Indicates all of adhesive on the tooth including a distinct impression of the bracket mesh.

COLOUR PLATE

FIG.1. 3M CERAMIC BRACKET KIT



FIG .2.ZIRCONIA BLOCKS



FIG .3. TOTAL ETCH ADHESIVE SYSTEM (TRANSBOND -XT)



FIG .4 SELF ETCH ADHESIVE SYSTEM (SCOTCHBOND UNIVERSAL)



FIG .5. ACRYLIC BLOCKS



FIG.6. CERAMIC PRIMER



Fig 7. LIGHTCURE UNIT

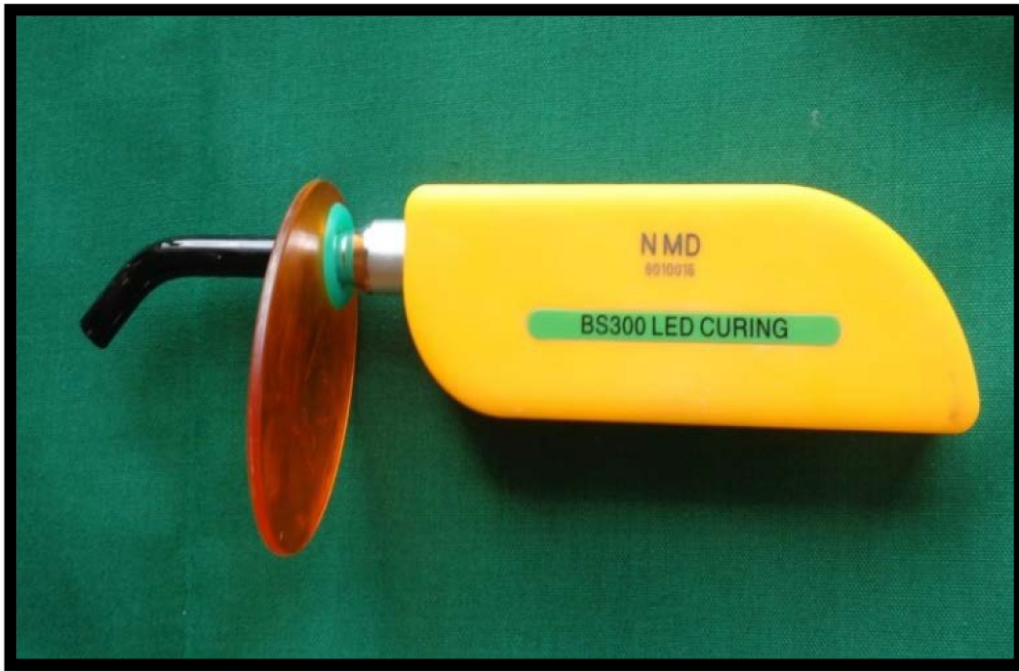


FIG 8.HYDROFLUORIC ACID



Fig.11.ARTIFICIAL SALIVA



Fig .12. SPECIMENS STORED IN ARTIFICIAL SALIVA

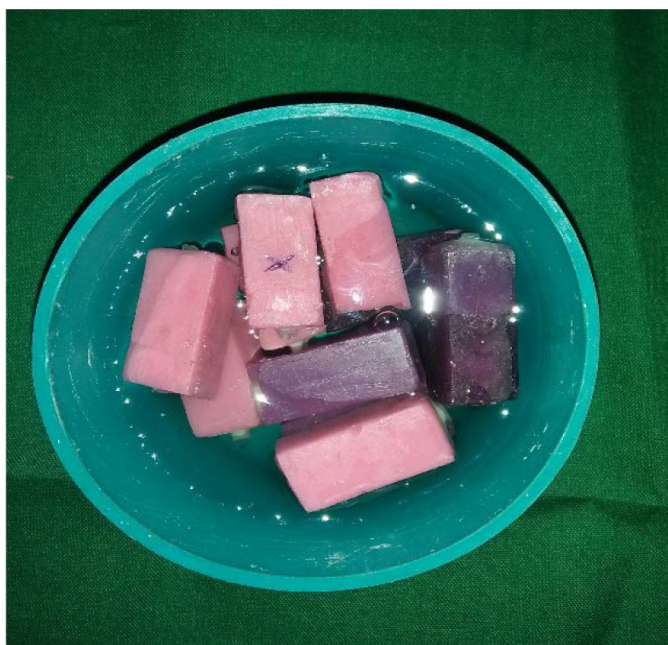


FIG.9. COMPOSITE RESIN



Fig .10.CERAMIC BRACKETS BONDED TO ZIRCONIA SURFACES



FIG .14. TESTING SHEAR BOND STRENGTH



FIG .13.INSTRON UNIVERSAL TESTING MACHINE



FIG .15.STEREOMICROSCOPE

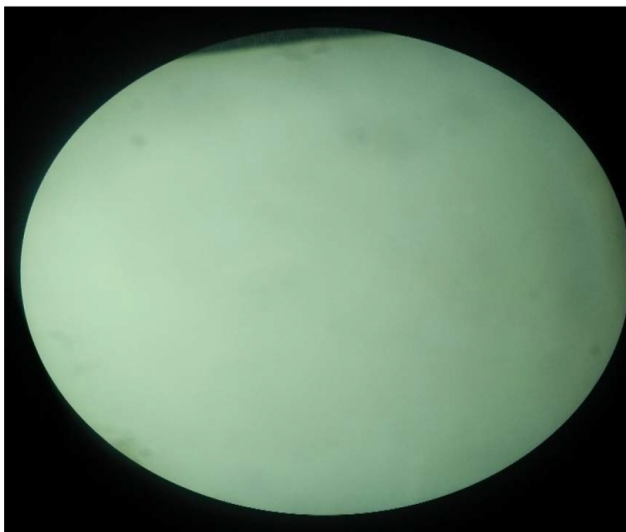


FIG .16.STEREOMICROSCOPE EXAMINATION OF THE DEBONDED SURFACES

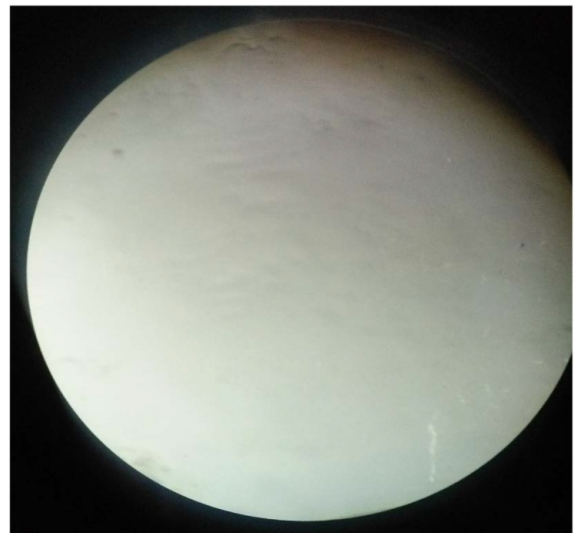


FIG .17.STEREO MICROSCOPE VIEW OF DEBONDED ZIRCONIA SURFACE –AFTER USE OF

TRANSBOND XT,



SCOTCHBOND



RESULTS

Twenty four specimens were divided into two groups of 12 specimens each. A total of two tests were conducted .

The shear bond strengths of the two groups were tested with the Instron universal testing machine; breaking load at which bond failure occurred was recorded in Newtons and bond strength was calculated using the formula :

$$\text{Bond strength} = \text{Breaking load} / \text{Nominal area of bonding base}$$

Bond strengths obtained in the study are shown in table 1.

Statistical Analysis:

This data was statistically evaluated using the following analysis.

1. Student t Test (Independent sample t Test)

Student t test was employed to compare the values in two independent groups .This can be applied in two situations and the formula for each varies.

- a. Sample variances are equal
- b. Sample variances are unequal

When the sample variances are equal the following the formula can be applied

$$t = (X_1 - X_2) / \sqrt{S^2 \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}$$

X_1 and X_2 = Sample means

S^2 = Sample variance

n1 and n2 =sample sizes for the 2 groups to be tested

The calculated value of t in the equation follows a t distribution with (n1+n2-2)degrees of freedom.

When the sample variances are unequal the following formula can be applied

$$t = \frac{X_1 - X_2}{\sqrt{\left(\frac{s^2}{n_1} + \frac{s^2}{n_2}\right)}}$$

This follows a t distribution with n-1 degrees of freedom provided. n=n1=n2

The data obtained for shear bond strength and adhesive remnant index were tabulated in an excel sheet (Microsoft excel version) and analysed statistically using SPSS software (version). Since the data for bond strength were quantitative in nature, it was assessed for normality and variance homogeneity using Shapiro Wilk and Levene's tests, followed by Independent sample test to know the statistical significance between groups. The adhesive remnant index scores were considered as categorical data and the association between the type of bond failure and bonding agents were analysed using Fisher Exact test. The p value was considered significant at 5% (p<0.05).

Shear bond strength

The shear bond strengths values (MPa) of all the twelve samples in both the groups (total etch and self-etch) were mentioned in table (1). The data were assessed for normality using Shapiro Wilk test and found to be normal in distribution. Hence Independent samples test was used to identify the significance between two groups. The mean, SD and SEM are mentioned in table (-2-). From the table (2), it is observed that the mean bond strength of self-

etch group (6.21 \pm 0.76) was slightly higher (10.51%) than mean of total etch group (5.59 \pm 1.37).

Table 3 shows the Independent sample test outcome, which shows that the variances between two groups were homogenous in nature ($p = 0.098$ from Levene's test of homogeneity) and p value is 0.190 (>0.05) indicating that both the groups were statistically not significant.

Adhesive Remnant Index

The adhesive remnant index of all the samples in both groups were tabulated (table 4) according to the scoring criteria developed by Artun and Bergland ⁽¹⁵⁾. There were no adhesive left out on the tooth (score 0- adhesive failure at tooth-resin interface) in majority of the samples in both the groups and few samples had less than half the amount of adhesive left (score 1-cohesive failure within the resin) on the tooth. Hence majority of the specimens underwent adhesive failure at tooth-resin interface than cohesive failure. None of the samples in both the group had scores 2 and 3, which shows that the bond strength between the resin-bracket interface was stronger in both total etch and self-etch group compared to tooth-resin interface.

The above data were analysed using Fisher's Exact test and it revealed that the distribution of scores 0 and 1 among both the groups were statistically insignificant ($p=0.640$).

TABLE-1

SHEAR BOND STRENGTH (In MPa)

SERIAL NO	TOTAL ETCH	SELF ETCH
	Bond strength (MPa)	Bond Strength (MPa)
1	6.14	6.71
2	5.62	6.43
3	5.25	5.01
4	4.36	6.26
5	4.71	6.84
6	5.71	7.54
7	7.54	6.42
8	4.50	5.57
9	8.50	5.03
10	4.16	6.84
11	4.22	5.70
12	6.41	6.13

TABLE-2

Group Statistics

Groups	N	Mean	Std. Deviation	Std. Error
ShearBondStren Total	12	5.5933	1.37423	.39670
gth Etch	12	6.2067	.76373	.22047
Self Etch	12	6.2067	.76373	.22047

Statistical Software used: SPSS Version 16

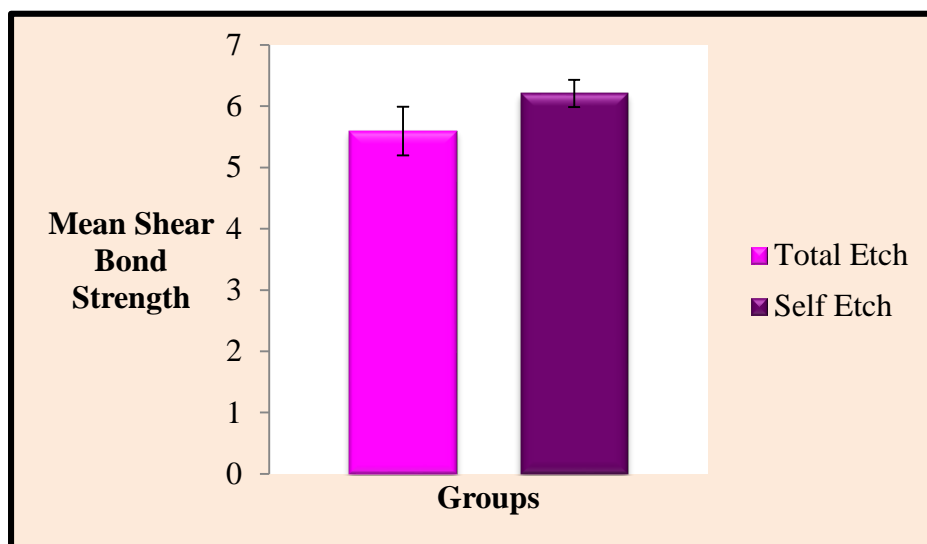
Statistical Test used: Independent sample t Test

TABLE-3

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed) P VALUE	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
ShearBondStrength	Equal variances assumed	2.985	.098	-1.351	22	.190	-.61333	.45385	-1.55456	.32790
	Equal variances not assumed			-1.351	17.203	.194	-.61333	.45385	-1.57002	.34335

FIGURE-1



ADHESIVE REMNANT INDEX

0	Indicates no adhesive left on the tooth
1	Indicates less than half of adhesive left on the tooth
2	Indicates more than half of adhesive left on the tooth
3	Indicates all of adhesive on the tooth including a distinct impression of the bracket mesh.

TABLE-4

Groups * AdhesiveRemanentIndex Crosstabulation

		AdhesiveRemanentIndex		Total
		Score 0	Score 1	
Groups Total	Count	8	4	12
Etch	% within Groups	66.7%	33.3%	100.0%
	% within AdhesiveRemanentIndex	44.4%	66.7%	50.0%
Self Etch	Count	10	2	12
	% within Groups	83.3%	16.7%	100.0%
	% within AdhesiveRemanentIndex	55.6%	33.3%	50.0%
Total	Count	18	6	24
	% within Groups	75.0%	25.0%	100.0%
	% within AdhesiveRemanentIndex	100.0%	100.0%	100.0%

TABLE-5

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.889 ^a	1	.346		
Continuity Correction ^b	.222	1	.637		
Likelihood Ratio	.902	1	.342		
Fisher's Exact Test				.640	.320
Linear-by-Linear Association	.852	1	.356		
N of Valid Cases ^b	24				

a. 2 cells (50.0%) have expected count less than 5.b. The minimum expected count is 3.00.

c. Computed only for a 2x2 table

FIGURE-2

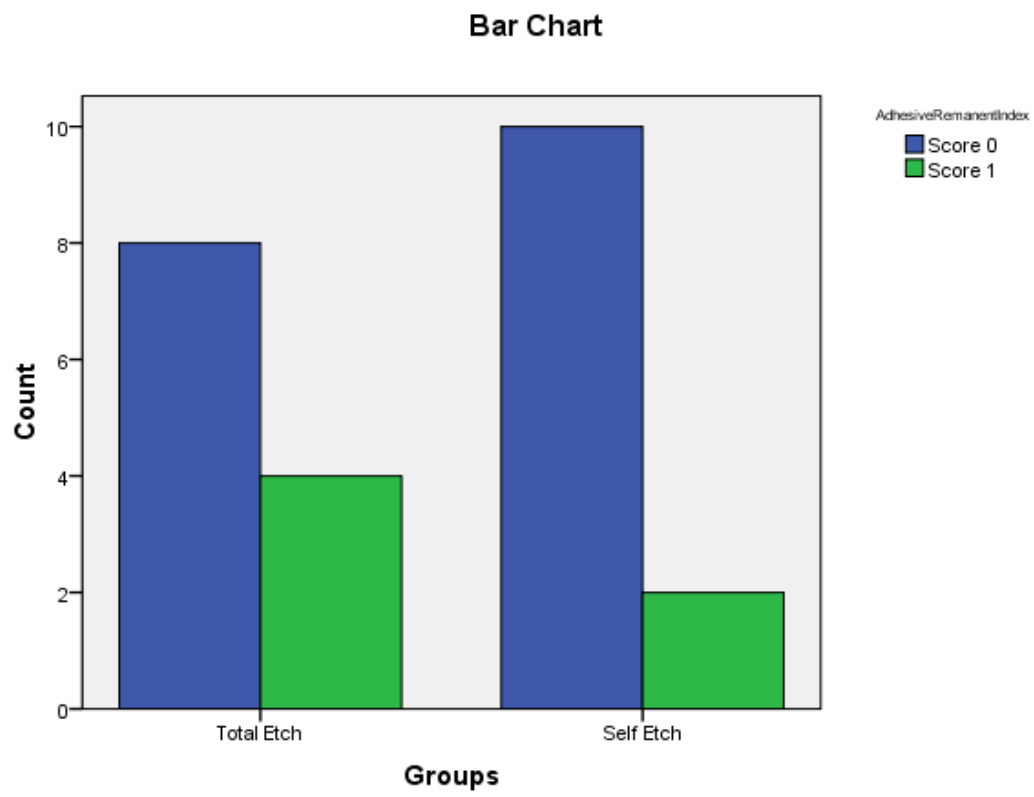
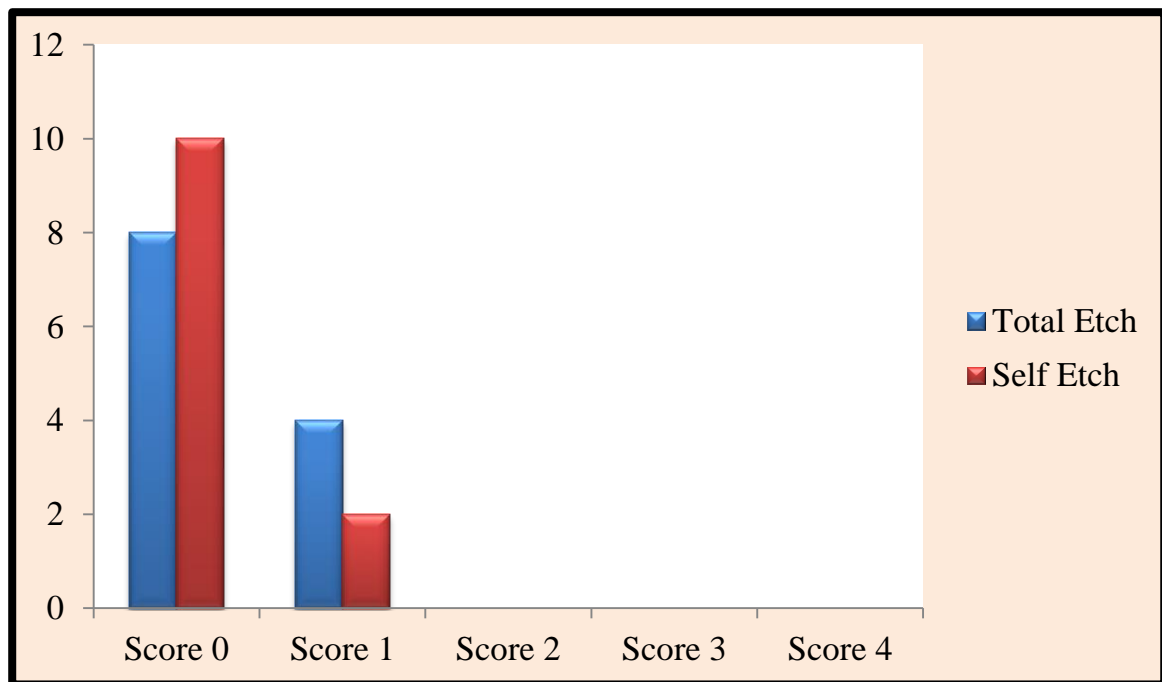


FIGURE-3



Independent sample t test used to evaluate the shear bond strength of Group 1 and Group II.

Chi square test was used and test ARI scores among the two groups.

Group I(Total etch technique) showed a mean shear bond strength of 5.6 MPa.

Group II (Self etch technique) showed a higher mean shear bond strength of 6.2 MPa.

This is depicted in tables 1&2 and Figure 1

The ARI score of 0 was found in 10 out of 12 specimens in group II and 8 out of 12 specimens in group 1. ARI score of 1 was found in 2 out of 12 specimens in group II and 4 out of 12 specimens in group 1 (Table-4, Figs-2&3)

DISCUSSION

Ever since the introduction of direct bonding of orthodontic brackets in fixed appliance mechanotherapy, enormous improvements have occurred in the range of the orthodontic direct bonding adhesives and materials available.⁽⁶⁵⁾ Moreover, due to the growing demand towards adult orthodontics and the esthetic concerns during delivery of orthodontic treatment, 'esthetic orthodontics' is in vogue and ceramic brackets are being preferred to metallic brackets.^(46,58) Meanwhile, it is not uncommon to witness adult patients with ceramic crowns and direct bonding of ceramic brackets onto ceramic surfaces has become a necessity. Ways and means to improve bond strength between ceramic crowns and ceramic brackets are also being analysed and researched upon.^(7,8,19,44,49,51,56,) In the present study two adhesive systems namely total etch system (Transbond XT–singlebond) and self-etch system –(Scotchbond universal) were evaluated for shear bond strength when used to bond polycrystalline ceramic brackets to zirconia surfaces.

The total etch bonding system using Transbond XT, is one of the standard adhesive systems used for direct bonding in orthodontics. This total etching system consists of four components, namely: Hydrofluoric acid –Porcelain conditioner, porcelain primer, bonding agent – Transbond XT single bond and adhesive resin.⁽⁷⁾ Introduction of Self etching primers was a breakthrough in direct bonding system, as it reduced working time and decreased procedural errors by being an one step adhesive, combining etching and priming steps.⁽²⁾ The self-etch system consists of two components, namely bonding agent-scotch bond universal and adhesive resin.⁽³⁾

In orthodontic patients with monolithic zirconia crowns, ceramic brackets are preferred and are directly bonded onto the zirconia surfaces. The bonding surfaces are roughened to increase the mechanical retention and therefore their bond strength. Various mechanical and chemical methods other than etching protocol on the bonding surfaces are followed for different types of ceramics, like metal ceramic, zirconia in order to improve bond strength. To avoid micro cracks of ceramic surfaces minimal roughening is preferred. Zachrisson et al⁽²¹⁾ recommended sandblasting of porcelain surfaces to obtain strong bonds followed by etching with a hydrofluoric acid or APF gel. They also suggested silane primer to increase bond strength.

As adhesive forces are best measured in –vitro by shear bond tests and the results obtained are usually converted from N/mm² into MPa,⁽⁶⁴⁾ this study tested for bond strength between zirconia surface and ceramic brackets when two types of bonding systems were used in MPa. The mean shear bond strengths while using (Group 1) Transbond XT single bond system in this study ranged from 4.16 to 6.41 MPa, with a mean value of 5.6 MPa.

The mean shear bond strengths while using (Group 2) scotch bond universal system ranged from 5.1 to 7.5 MPa, with a mean value of 6.2 MPa. The optimal shear bond strength suggested by Reynolds was 5.9 to 7.8 MPa⁽¹³⁾ (Group 2 (self etch) - 6.2 MPa). The shear bond strengths therefore using Total etch system was marginally lesser and that when using self-etching system was within the acceptable range of ideal bond strength for holding brackets during orthodontic treatment.

Elham S.J. Abu Alhaija et al⁽⁸⁾ in their study reported higher shear bond strengths of 15 MPa when using Transbond XT to bond ceramic brackets to hydrofluoric acid etched ceramic crowns. They stressed upon surface treatment of the

ceramic bonding surface to obtain high shear bond strengths, which included sandblasting of the ceramic crown surfaces followed by Hydrofluoric acid etching.⁽⁸⁾ In the present study (group 1) the total etch system involved use of hydrofluoric acid alone as etchant with no sandblasting and could be the reason for the comparatively lower bond strength .

Arnold et al⁽⁶¹⁾ reported shear bond strength of 9.7MPa when using Transbond XT to bond metal brackets to enamel surfaces. The variation in bond strength between these two studies could be due to the different bonding surfaces and hence different etching solutions, namely phosphoric acid and hydrofluoric acid.⁽⁶¹⁾

Hellak et al ⁽⁷⁾ conducted a study to determine shear bond strength when Transbond total etching system was used to bond on various prosthetic surfaces including the ZirCAD ceramic surface. They reported the shear bond strength between ceramic surface and total etch system bonded composite to be 4.29 MPa, which was a lower shear bond strength as compared to values of this study. Metal brackets were used in the study by Hellak et al ⁽⁷⁾ while clarity (3M unitek USA) ceramic brackets were used in this study. Since both brackets have differing base surface structure and the bond between metal- composite and ceramic – composite is different, the bonding strength could have been better between two ceramic surfaces.

In the present study, the mean shear bond strengths while using scotch bond universal system (Group 2) ranged from 5.70 to 7.54MPa, with a mean value of 6.2 MPa.

Sasiwimol et al⁽⁴⁹⁾ in their study tested the shear bond strength between resin composite bonded using Adper scotch bond plus(3m unitek, USA) self etch system

and zirconia ceramic specimens ,without using orthodontic brackets and measured shear bond strength values of 15.6 ± 1.2 MPa, as did other recent studies which stated that phosphate monomers in the bonding agent play a key role in providing good bond with zirconia. The scotch bond universal self-etch adhesive also contains 10-methacryloxydecyl dihydrogen phosphate(MDP) which is said to account for the enhanced bonding on the zirconia surfaces .Such phosphate monomers form chemical bonds with the zirconia surfaces and have polymerizable resin terminal end groups(eg.methacrylate)thereby enabling cohesive bonding to appropriate resins^(33,44) Such high shear bond strengths greater than 13 MPa ,could probably be attributed to the intimate micromechanical bond to zirconia surface However shear bond strengths more than optimal are undesirable in clinical situations for fear of producing cracks on the bonding surface during debonding.^(56,62)

Samir E. Bishara et al⁽²⁹⁾ also reported mean shear bond strength of 7.1 MPa, which was clinically acceptable, when a self etch primer was used to bond orthodontic metal brackets to enamel surfaces, which is marginally higher than results of this study.

In this study Group 2 (self etch system) showed higher mean shear bond strength than group 1 (Transbond XT) when used for bonding ceramic brackets to zirconia surfaces .This is in agreement with the study of Andreas Hellak Et al⁽⁷⁾ who conducted a study to determine SBS when Transbond total etching system was used to bond on various prosthetic surfaces including ceramic surfaces. They reported the shear bond strength between ceramic surface and total etch system bonded composite to be 4.29 MPa and concluded that scotch bond universal self-etch primer provided

the best mean shear bond strength on prosthetic surfaces (metal ,porcelain, composite);12.33MPa on ZIRCAD.

The higher bond strengths of the Self etching adhesives has been related to aqueous components which are hydrophilic,there by attracting water molecules and hence displacing moisture from the bonding surface and permitting bonding without any obstruction. This property can be advantageously used for bonding in a moist environment.⁽³¹⁾

The scotch bond universal self-etch adhesive contains 10- methacryloxydecyl dihydrogen phosphate(MDP) which accounts for the enhanced bonding on the zirconia surfaces .Such phosphate monomers form chemical bonds with the zirconia surfaces and have polymerizable resin terminal end groups(eg.methaacrylate)thereby enabling cohesive bonding to appropriate resins.^(33,44)

Bowen and Rodriguez⁽²⁶⁾in 1962 concluded that the mean cohesive strength of enamel was about 10.3 N/mm^2 .Reynolds⁽¹³⁾ in 1975 stated that the Shear bond strength of bonding agents should not be below the cohesive strength of enamel, which is 10.3 N/mm^2 , so as to avoid enamel fractures during debonding .Ebert et al⁽⁵⁶⁾reported that though debonding of brackets from prosthetic tooth surfaces bracketsmay not damage the enamel, itwould always have a risk of inducing defects or cracks on the prosthetic surfaces. In this study, it was found that the bond strength of total etch system was 5.6 MPa and self etch system was 6.2 MPa, which were below the set cohesive strength of enamel. Hence both the systems fulfill the requirements of being sufficiently strong and retain the brackets but simultaneously low enough to allow easy cleanup of the adhesives when brackets are deboned(Powers JM,Meassersmith ML 2001).⁽⁶³⁾Generally the bond strength of the

adhesive used for direct bonding in orthodontics should only be high enough to resist the forces that arise in the orofacial region ⁽⁷⁾. In addition, the bonding adhesive must also be easy to remove without causing iatrogenic damage to the enamel or prosthetic surface. The adhesive remnant Index (ARI) is one of the most commonly used methods of assessing the quantum of adhesion between the bonding agents, tooth or prosthetic surface and bracket bases. ⁽¹⁵⁾

Lesser ARI scores are clinically advantageous, as the least adhesive remnant found on the substrate base, make clean-up of the tooth or prosthetic surfaces easier and faster. ^(52,29). Higher ARI scores indicate breakage at adhesive-bracket interface, leaving much of remnants and thus requiring a lot of clean-up of the tooth surfaces or the prosthetic surface.

The secondary aim of this study was therefore, to find the adhesive remnant index (ARI) while using these two bonding systems. Stereo microscopic analysis was done to find the adhesive remnants on the ceramic surfaces. In this study, ARI score of 0 was seen in 8 out of 12 specimens in Group 1 (Total etch system) and 10 out of 12 specimens in Group 2 (self etch system). The score of ARI 1 inferred that less than 50% of the adhesive was left on the bonding surface which were seen in 4 out of 12 specimens in Group 1 and 2 out of 12 specimens in Group 2.

ARI score of '0' indicated that almost no resin remained on the zirconia surface upon debonding on 66% and 83% of surfaces when total etch system and self etch system were used respectively. On a relative basis, the self etch system performed better in terms of ARI.

Limitation:

In vitro data should be carefully extrapolated to the clinical situation because of the complex oral environment. In vitro studies can be used as a screening mechanism for predicting clinical performance. The changes in temperature, humidity, acidity (pH), and the mechanical and masticatory stresses placed on a bracket in the oral cavity are impossible to be simulated in in-vitro conditions. However in vitro tests can provide impetus for in-vivo studies.

SUMMARY AND CONCLUSION

Adult orthodontics is becoming more popular in present times. Since prosthetic restorations with ceramic crowns are also witnessed more frequently, the need to bond ceramic brackets onto ceramic crowns have become a necessity. It is important to have a good bond strength for efficient treatment delivery. Since studies reporting about bond strengths of total etch and self etching systems, when used for bonding ceramic brackets to ceramic surfaces are sparse, this in vitro study was conducted to evaluate the bond strength of the two different orthodontic bonding systems, namely Total etch & self etch systems used for bonding ceramic brackets to zirconia surfaces.

Zirconia slabs were embedded onto acrylic blocks and ceramic brackets were bonded on them using both total and self etching systems. The bond strengths of the two groups were tested. In addition, the adhesive remnants on the zirconia surfaces upon debonding were also evaluated, using stereo microscope.

The following conclusions were made:

1. The mean shear bond strength of self etch system was 6.2MPa, which was adequate enough to provide good bond strength.
2. The mean shear bond strength of Total etch system was 5.6MPa, which was marginally lesser than the required bond strength
3. The self etching system had a higher bond strength as compared to the Total etch system, though statistically insignificant.
4. The adhesive remnant index for self etch ARI score of '0' on 66% and 83% of surfaces when total etch system and self etch system were used respectively.

5. Considering the other reported advantages of self etching system to be minimizing bonding steps , time consumption and ability to bond on wet surfaces adequately, the self etching system appears to be preferable to total etch system for bonding ceramic brackets on zirconia crowns.

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